APPENDIX A

CONTROL CHART VARIABLES DATA (X-BAR & R)

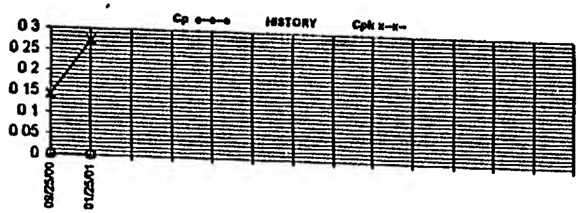
DATA PASSED NORMALITY TEST YES NO

MEASUREMENT GAUGE TO USE	PELT GAGE
BACKUP MEASUREMENT GAUGE	ELCOMETER
SC #	0
DATA CONTROL LIMITS CALCULATED FROM	9/25/00
MACH NO	PRIME BOOTH
SAMPLE SIZE	1 UNIT
LOCATIONS DATA COLLECTED	PELT BOOTH
LINE X LIMITS	CALCULATED
BAR A - INITIAL LIMITS	HISTORICAL
BAR B - PREVIOUS LIMITS	HISTORICAL
PLANT	DEMO
ENGINEERING SPECIFICATION	0.90 Minimum Unilateral
PANEL	Left
SAMPLE FREQUENCY	2/SHIFT
CHART CHAMPION	FILM ANALYST
DEPARTMENT	PAINT
DATE OF MEASUREMENT STUDY / P VALUE (%)	
CHARACTERISTIC	Taupe Prime
CONTROL ITEM	YES ☐ NO ☐
CHART BUDDY	PROCESS ENGINEER

LAST CALCULATED LINE X LIMITS	UCLX	CLX	LCLX	UCLR	CLR	LCLR	CP	CPK
10/18/00 to 03/21/01	1.20	1.07	0.94	1.29	0.83	0.38	0.000	0.272
HISTORICAL LINE X LIMITS: na to na	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000

LINE X-BAR: na LINE R-BAR: na

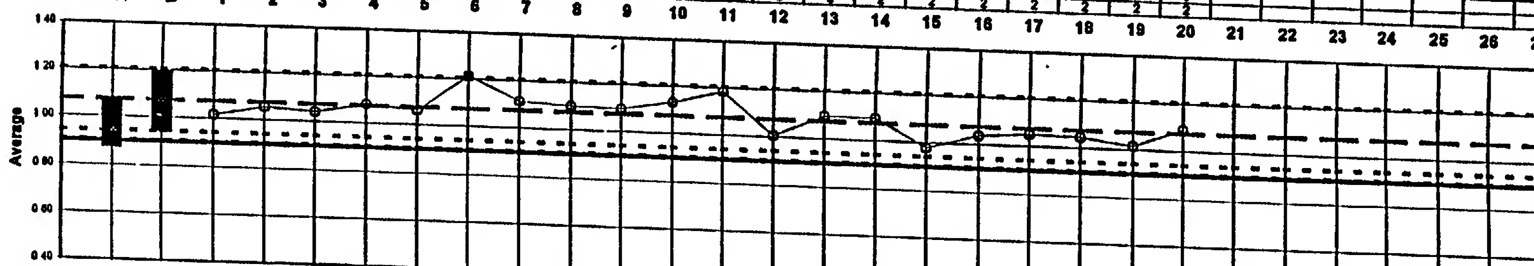
REACTION PLAN #

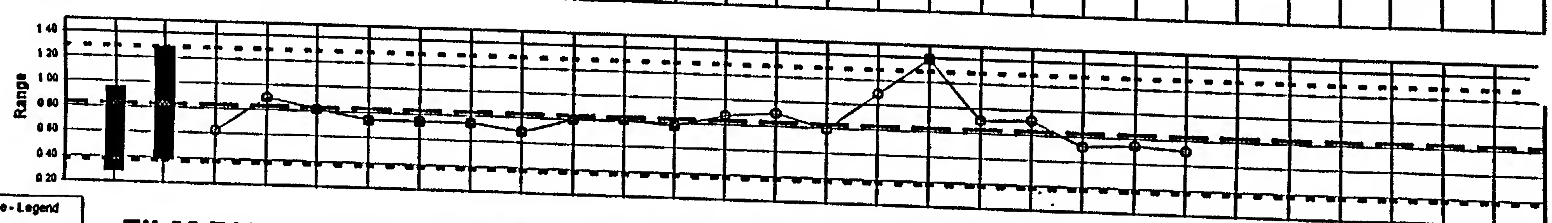


Average - Legend: CLXbar; UCLXbar&LCLXbar; LSL

Unit of Measure MIL

	A	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Date			10/10	10/12	10/16	10/23	10/23	10/27	10/31	10/31	11/7	11/10	11/13	11/20	11/23	11/27	11/28	11/29	12/4	12/6	12/8	3/21							
Average			1.02	1.05	1.04	1.08	1.06	1.21	1.11	1.10	1.09	1.13	1.18	1.01	1.09	1.09	0.98	1.03	1.05	1.05	1.02	1.09							
Range			0.62	0.90	0.81	0.74	0.74	0.74	0.68	0.80	0.81	0.77	0.87	0.90	0.79	1.09	1.39	0.90	0.92	0.72	0.74	0.71							
Minimum			0.708	0.605	0.587	0.701	0.622	0.812	0.737	0.69	0.648	0.737	0.744	0.587	0.648	0.581	0.45	0.594	0.587	0.666	0.639	0.711							
Maximum			1.33	1.503	1.4	1.439	1.365	1.555	1.421	1.488	1.457	1.511	1.615	1.486	1.439	1.67	1.835	1.493	1.503	1.385	1.382	1.423							
Style			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5							
Shift			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2							





Range - Legend: Rbar; UCLRbar/LCLRbar

FILM BUILD SPC

PAINT APPLICATIONS TEAM

		UCLX	CLX	LCLX	UCLR	CLR	LCLR
BAR A	CALCULATED - INITIAL LIMITS SET FROM na to na	na	na	na	na	na	na
BAR A	HISTORICAL - INITIAL LIMITS SET FROM 5/15/98 to 9/25/98	1.07	0.97	0.87	0.96	0.62	0.28
BAR B	CALCULATED - PREVIOUS LIMITS SET FROM na to na	na	na	na	na	na	na
BAR B	HISTORICAL - PREVIOUS LIMITS SET FROM 10/10/00 to 3/12/01	1.20	1.07	0.94	1.29	0.83	0.38

ANNOTATION SECTION

NOTE: USER MAKES DECISION CONCERNING NORMALITY

LINE X HAS THE ABILITY TO SHIFT WITH CONTROL LIMITS

SPECIFICATION LINES FILTER OPTION IS DISPLAYED

APPENDIX B

INDIVIDUAL MOVING RANGE CONTROL CHART

DATA PASSED NORMALITY TEST YES NO

REACTION PLAN #

MEASUREMENT GAGE: PELT GAGE
0
DATA CONTROL LIMITS CALCULATED FROM
MACH NO: PRIME BOOTH
SAMPLE SIZE
LOCATIONS DATA COLLECTED: PELT BOOTH
LIMIT CALCULATED

PLANT: DEMO
ENGINEERING SPECIFICATION: 0.90 Minimum Unilateral
PANEL: Specific Point
POINT: 22
SAMPLE FREQUENCY: 2/SHIFT
CHART CHAMPION: FILM BUILD ANALYST

BACKUP MEASUREMENT GAUGE: ELCOMETER

DEPARTMENT: PAINT
DATE OF MEASUREMENT STUDY / P VALUE (%)
CHARACTERISTIC: Taupe Prime
CONTROL ITEM
CHART BUDDY: PROCESS ENGINEER

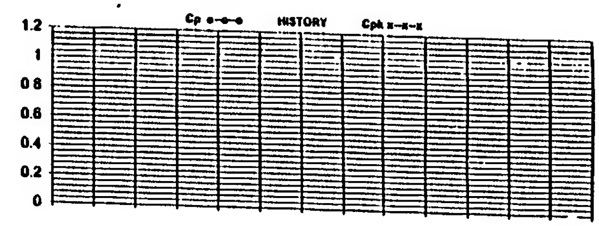
YES ☐ NO ☐

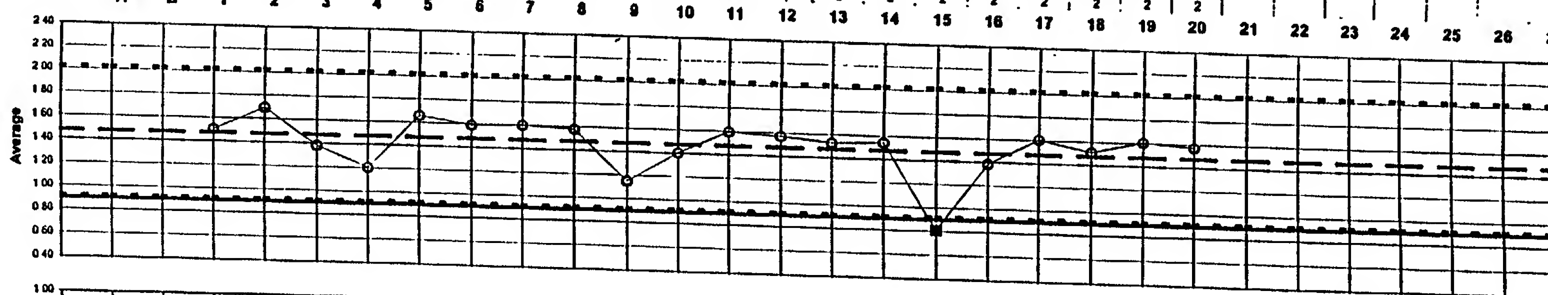
BAR A - INITIAL LIMITS: DISABLED
BAR B - PREVIOUS LIMITS: DISABLED
Unit of Measure: MIL

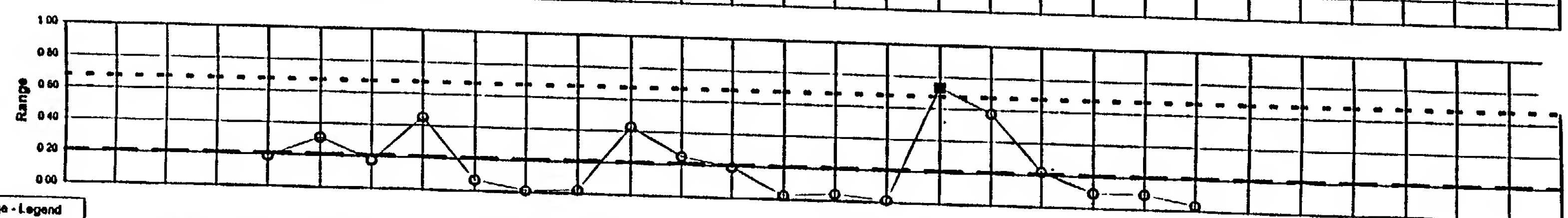
		UCLX	CLX	LCLX	UCLR	CLR	LCLR	CP	CPK
LAST CALCULATED LINE X LIMITS	10/10/00 to 12/21/01	2.03	1.47	0.92	0.68	0.21	na	0.000	1.040
HISTORICAL LINE X LIMITS	na to na	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.000

Average - Legend
CLXbar
UCLXbar/LCLXbar
USL/LSL

	A	B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Date			10/10	10/12	10/16	10/23	10/23	10/27	10/31	10/31	11/7	11/10	11/13	11/20	11/23	11/27	11/28	11/29	12/4	12/6	12/8	12/21							
Value			1.50	1.69	1.38	1.21	1.66	1.59	1.60	1.58	1.15	1.40	1.60	1.57	1.53	1.54	0.81	1.39	1.61	1.51	1.61	1.57							
Range				0.19	0.31	0.18	0.45	0.07	0.01	0.02	0.43	0.25	0.19	0.03	0.04	0.01	0.73	0.58	0.22	0.10	0.10	0.03							
Style			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	5							
Shift			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2							







Range - Legend
MRbar
UCLMRbar/ LCLMRbar

FILM BUILD SPC

PAINT APPLICATIONS TEAM

		UCLX	CLX	LCLX	UCLR	CLR	LCLR
BAR A	CALCULATED - INITIAL LIMITS SET FROM na to na	na	na	na	na	na	na
	HISTORICAL - INITIAL LIMITS SET FROM na to na	0.00	0.00	0.00	0.00	0.00	0.00
BAR B	CALCULATED - PREVIOUS LIMITS SET FROM na to na	na	na	na	na	na	na
	HISTORICAL - PREVIOUS LIMITS SET FROM na to na	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX C

FILM BUILD EXECUTIVE SCHEMATIC (RIGHT AND LEFT SIDES)

MEASUREMENT GAUGE TO USE: PELT GAGE
UNIT OF MEASURE: MIL
MACH. NO
PRIME BOOTH
SAMPLE SIZE
CHART CHAMPION
FILM ANALYST

PLANT: DEMO
PANEL: <Exec. Schematic>
SAMPLE FREQUENCY: 2/SHIFT
CHART BUDDY: PROCESS ENGINEER

BACKUP MEASUREMENT GAUGE: ELCOMETER

DEPARTMENT: PAINT
CHARACTERISTIC: Taupe Prime
LOCATIONS DATA COLLECTED: PELT BOOTH
EXECUTIVE SCHEMATIC SUBGROUP: 10/10/00 to 03/21/01

BOOTH: na

	MIN - AVG - MAX	MIN - 6SIGMA - MAX
	0.90 1.10	0.00 1.00

DATA RECORD COUNT: 20

LEGEND

Average (X)	6 Sigma (s*6)

Data out of spec is underlined and shaded

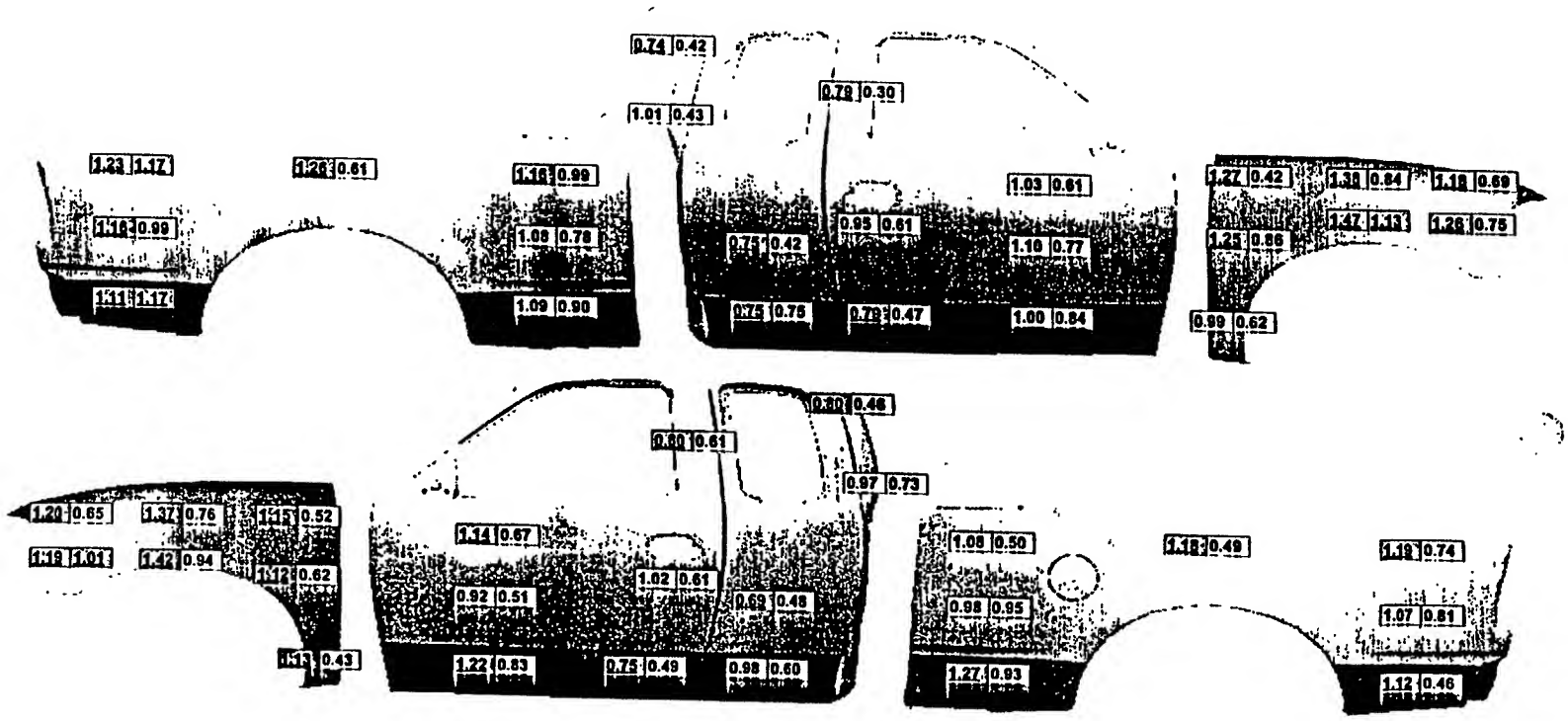
FILM BUILD SPC

PAINT APPLICATIONS TEAM

ANNOTATION SECTION

Retrieval System allows storage of Schematic for electronic distribution and review.

Profile includes coatings' averages, process performance and the number of units measured.



APPENDIX D

Film Build Cpk's Cost Impact Analysis

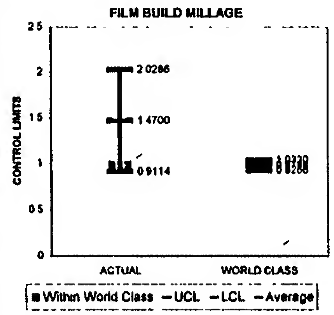
1ST PREMISE

VARIATION SELECTION
1) Choose Variability
2) Select First Target Range
3) Average Adjusted to World Class Standard

Coating Taupe Prime
Point 22
Booth na

Coating Min Spec	0 9
Actual Average	1 47
Actual Range	0 21
Actual Cpk	1 04
Target Range:	0 02
World Class Cpk	1 5
Effect on Coating Usage	-33.35%

Approximate Annualized Cost Impact
$ (1,418 12)



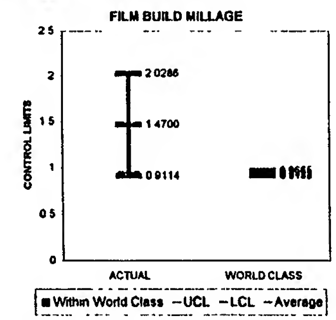
2ND PREMISE

VARIATION SELECTION
1) Choose Variability
2) Select Second Target Range
3) Average Adjusted to World Class Standard

Coating Taupe Prime
Point 22
Booth na

Coating Min Spec.	0 9
Actual Average	1 47
Actual Range	0 21
Actual Cpk	1 04
Target Range:	0 01
World Class Cpk	1 5
Effect on Coating Usage	-36 06%

Approximate Annualized Cost Impact
$ (1,533.52)



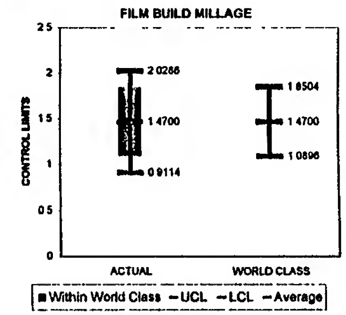
3RD PREMISE

VARIATION REDUCTION
1) Variability Adjusted to World Class Standard
2) Coating Usage Remains Consistent
3) Average Remains Constant

Coating Taupe Prime
Point 22
Booth na

Coating Min Spec:	0 9
Actual Average.	1 47
Actual Range	0 21
Actual Cpk	1 04
New Range:	0.14
World Class Cpk.	1 5
Effect on Coating Usage	0.00%

Approximate Annualized Cost Impact
$ nil



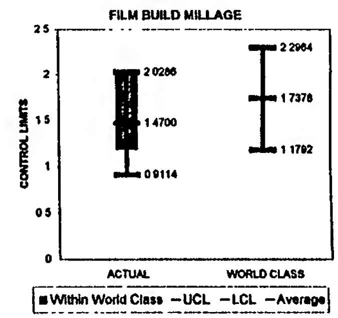
4TH PREMISE

INCREASED MILLAGE
1) Coating Usage Increases
2) Variability Remains Constant
3) Average Adjusted to World Class Standard

Coating Taupe Prime
Point 22
Booth na

Coating Min. Spec:	0 9
Actual Average.	1 47
Actual Range.	0 21
Actual Cpk.	1 04
New Average:	1.74
World Class Cpk.	1 5
Effect on Coating Usage	18.22%

Approximate Annualized Cost Impact
$ 774 61



Cost per Unit Factors:							
Coating	Point	Usage per Unit (gal)	Cost per Gallon ($)	Coating Popularity %	Point %	Booth % Flow	Annualized Production (units)
Taupe Prime	22	0 27	30 00	25	1 05	100	200,000

CONSTANTS AND FORMULAS

FORMULA FOR $\bar{X}$ AND R CHARTS

$\bar{X}$ - Chart

$$\bar{X} = \frac{\Sigma X}{n}$$

$$CL\bar{X} = \bar{\bar{X}} = \frac{\Sigma \bar{X}}{k}$$

$$UCL\bar{X} = \bar{\bar{X}} + (A_2 \times \bar{R})$$

$$LCL\bar{X} = \bar{\bar{X}} - (A_2 \times \bar{R})$$

R - Chart

$$CLR = \bar{R} = \frac{\Sigma R}{k}$$

$$UCLR = D_4 \times \bar{R}$$

$$LCLR = D_3 \times \bar{R}$$

$$\hat{\sigma} = \frac{\bar{R}}{d_2}$$

$$Cp = \frac{USL - LSL}{6\hat{\sigma}}$$

$$Cpk = \text{minimum of } \frac{USL - \bar{\bar{X}}}{3\hat{\sigma}} \text{ or } \frac{\bar{\bar{X}} - LSL}{3\hat{\sigma}}$$

CONTROL CHARTS FOR VARIABLE DATA

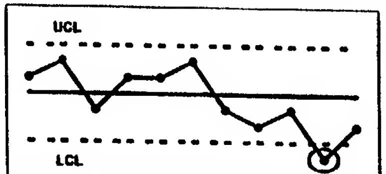
x	Individual Measurement
$\bar{x}$	Subgroup Average
$\bar{\bar{x}}$	Grand Average
Σ	Sum of
R	Range = Highest Value - Lowest Value
CL	Center Line
UCL	Upper Control Limit
LCL	Lower Control Limit
k	Number of Subgroups
n	Subgroup Size
$\hat{\sigma}$	Process Standard Deviation
A_2	Factor for $\bar{x}$ Chart Limits
D_4	Factor for UCL on R Chart
D_3	Factor for LCL on R Chart
USL	Upper Specification Limit
LSL	Lower Specification Limit
d_2	Factor for estimating Process Standard Deviation

Chart X

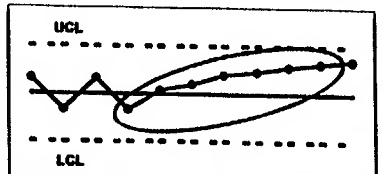
n Subgroup Size	A2 Upper and Lower Control Limit Factor
2	1.880
3	1.023
4	0.729
5	0.577
6	0.483
7	0.419
8	0.373
9	0.337
10	0.308
11	0.285
12	0.266
13	0.249
14	0.235
15	0.223
16	0.212
17	0.203
18	0.194
19	0.187
20	0.180
21	0.173
22	0.167
23	0.162
24	0.157
25	0.153

Range Chart R

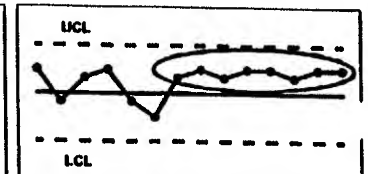
n Subgroup Size	d2 Estimate of Standard Deviation Divisor	D3 Lower Control Limit Factor	D4 Upper Control Limit Factor
2	1.128	na	3.270
3	1.693	na	2.574
4	2.059	na	2.282
5	2.326	na	2.114
6	2.534	na	2.004
7	2.704	0.076	1.924
8	2.847	0.136	1.864
9	2.970	0.184	1.816
10	3.078	0.223	1.777
11	3.173	0.256	1.744
12	3.258	0.283	1.717
13	3.336	0.307	1.693
14	3.407	0.328	1.672
15	3.472	0.347	1.653
16	3.532	0.363	1.637
17	3.588	0.378	1.622
18	3.640	0.391	1.608
19	3.689	0.403	1.597
20	3.735	0.415	1.585
21	3.778	0.425	1.575
22	3.819	0.434	1.566
23	3.858	0.443	1.557
24	3.895	0.451	1.548
25	3.931	0.459	1.541



A POINT OUTSIDE OR DIRECTLY ON THE CONTROL LINE



A TREND OF 7 CONSECUTIVE POINTS MOVING IN THE SAME DIRECTION, EITHER UPWARD OR DOWNWARD INDICATES A GRADUAL CHANGE IN THE PROCESS



SEVEN POINTS ABOVE THE CENTRAL LINE INDICATE THAT THE CENTER OF THE NORMAL DISTRIBUTION HAS STARTED UPWARD

CONSTANTS AND FORMULAS

APPENDIX F

Film Build Cpk's Cost Impact Analysis

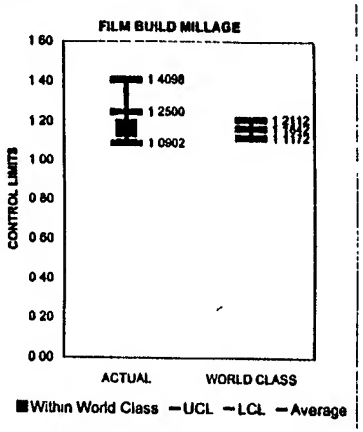
1ST PREMISE

VARIATION SELECTION
1) Choose Variability
2) Select First Target Range
3) Average Adjusted to World Class Standard

Coating: Black Prime
Panel. Hood
Booth: na

Coating Min. Spec:	0 9
Actual Average:	1.25
Actual Range:	0 68
Actual Cpk:	0 587
Subgroup Size.	14
Target Range:	**0.2**
World Class Cpk:	1.5
Effect on Coating Usage	**-6.87%**

Approximate Annualized Cost Impact
$ (3,754 55)



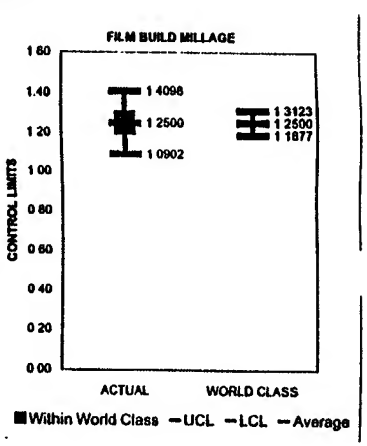
3RD PREMISE

VARIATION REDUCTION
1) Variability Adjusted to World Class Standard
2) Coating Usage Remains Consistent
3) Average Remains Constant

Coating: Black Prime
Panel. Hood
Booth: na

Coating Min. Spec.:	0.9
Actual Average:	1.25
Actual Range:	0.68
Actual Cpk:	0 587
Subgroup Size:	14
New Range:	**0.27**
World Class Cpk:	1 5
Effect on Coating Usage	**0.00%**

Approximate Annualized Cost Impact
$ nil



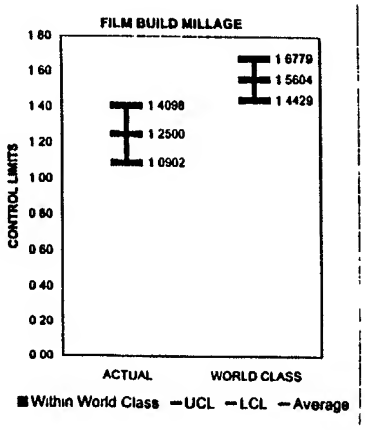
2ND PREMISE

VARIATION SELECTION
1) Choose Variability
2) Select Second Target Range
3) Average Adjusted to World Class Standard

Coating: Black Prime
Panel: Hood
Booth. na

Coating Min. Spec..	0 9
Actual Average:	1.25
Actual Range:	0 68
Actual Cpk:	0 587
Subgroup Size:	14
Target Range:	**0.5**
World Class Cpk:	1.5
Effect on Coating Usage	**24.83%**

Approximate Annualized Cost Impact
$ 13,577.12



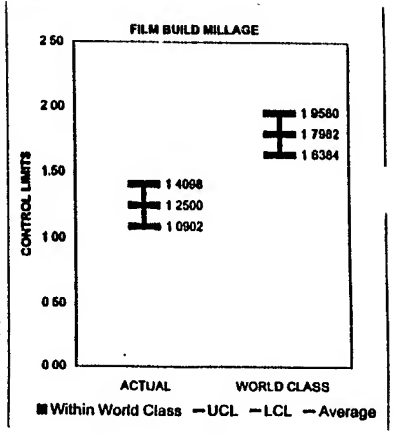
4TH PREMISE

INCREASED MILLAGE
1) Coating Usage Increases
2) Variability Remains Constant
3) Average Adjusted to World Class Standard

Coating: Black Prime
Panel. Hood
Booth: na

Coating Min. Spec.:	0.9
Actual Average:	1.25
Actual Range:	0.68
Actual Cpk:	0 587
Subgroup Size:	14
New Average:	**1.7982**
World Class Cpk:	1 5
Effect on Coating Usage	**- 43.85%**

Approximate Annualized Cost Impact
$ 23,976 12



Cost per Unit Factors:

Coating:	Panel:	Usage per Unit (gal):	Cost per Gallon ($):	Coating Popularity %:	Panel %:	Booth % Flow:	Annualized Production (units)
Black Prime	Hood	0 27	27	25	15	100	200,000

Automotive Facility
Booth 2 Clear Coat Film Build Cost Analysis

Panel	Millage Adjusted, Variability Constant	Range Variability Adjusted: 0.10 Mils	Range Variability Adjusted: 0.20 Mils
Left	$ 214,576	$ 7,333	$ 25,674
Right	$ 263,413	$ 22,571	$ 41,838
Hood	$ 161,393	($ 39,670)	($ 23,712)
Roof	$ 84,819	($ 19,053)	($ 505)
Deck	$ 40,453	($ 20,413)	($ 10,903)
Totals:	$ 764,654	($ 49,232)	$ 32,392

United States Patent & Trademark Office

Office of Initial Patent Examination -- Scanning Division

Application deficiencies found during scanning:

☐ Page(s)__________ of ____________________________ were not present for scanning. (Document title)

☐ Page(s)__________ of ____________________________ were not present for scanning. (Document title)

(1) NUMBER OF SHEETS OF DRAWINGS IS 2 NOT 9

(2) APPENDIX C IS DARK

☐ ***Scanned copy is best available.***